

Charles Robert Darwin, FRS. FRGS. FLS. FZS.

Charles Darwin spent long periods on the Isle of Wight, in 1881 staying at the Ocean Hotel in Sandown High Street. He was just putting the finishing touches to his ***The Formation of Vegetable Mould through the Action of Worms, with Observations on their Habits*** (sometimes shortened to *Worms*). On hearing about the Villa that had just been found at Brading, he sent his eldest son William Erasmus Darwin to visit the site to find out about the soil structure covering the Villa, this was incorporated in to the above book. It was his last scientific book, and was published shortly before his death. Exploring earthworm behaviour and ecology, it continued the theme common throughout his work that gradual changes over long periods of time can lead to large and sometimes surprising consequences.

Below is chapter 4 of the book describing the part worms play in the burial of ancient buildings, including Brading Roman Villa.

Chapter IV--The Part Which Worms Have Played In The Burial Of Ancient Buildings.

The accumulation of rubbish on the sites of great cities independent of the action of worms--The burial of a Roman villa at Abinger--The floors and walls penetrated by worms--Subsidence of a modern pavement--The buried pavement at Beaulieu Abbey--Roman villas at Chedworth and Brading--The remains of the Roman town at Silchester--The nature of the debris by which the remains are covered--The penetration of the tessellated floors and walls by worms--Subsidence of the floors--Thickness of the mould--The old Roman city of Wroxeter--Thickness of the mould--Depth of the foundations of some of the Buildings--Conclusion.

Archaeologists are probably not aware how much they owe to worms for the preservation of many ancient objects. Coins, gold ornaments, stone implements, etc., if dropped on the surface of the ground, will infallibly be buried by the castings of worms in a few years, and will thus be safely preserved, until the land at some future time is turned up. For instance, many years ago a grass- field was ploughed on the northern side of the Severn, not far from Shrewsbury; and a surprising number of iron arrow-heads were found at the bottom of the furrows, which, as Mr. Blakeway, a local antiquary, believed, were relics of the battle of Shrewsbury in the year 1403, and no doubt had been originally left strewed on the battle-field. In the present chapter I shall show that not only implements, etc., are thus preserved, but that the floors and the remains of many ancient buildings in England have been buried so effectually, in large part through the action of worms, that they have been discovered in recent times solely through various accidents. The enormous beds of rubbish, several yards in thickness, which underlie many cities, such as Rome, Paris, and London, the lower ones being of great antiquity, are not here referred to, as they have not been in any way acted on by worms. When we consider how much matter is daily brought into a great city for building, fuel, clothing and food, and that in old

times when the roads were bad and the work of the scavenger was neglected, a comparatively small amount was carried away, we may agree with Elie de Beaumont, who, in discussing this subject, says, "pour une voiture de materiaux qui en sort, on y en fait entrer cent." {53} Nor should we overlook the effects of fires, the demolition of old buildings, and the removal of rubbish to the nearest vacant space,

Abinger, Surrey.--Late in the autumn of 1876, the ground in an old farm-yard at this place was dug to a depth of 2 to 2.5 feet, and the workmen found various ancient remains. This led Mr. T. H. Farrer of Abinger Hall to have an adjoining ploughed field searched. On a trench being dug, a layer of concrete, still partly covered with tesserae (small red tiles), and surrounded on two sides by broken-down walls, was soon discovered. It is believed, {54} that this room formed part of the atrium or reception-room of a Roman villa. The walls of two or three other small rooms were afterwards discovered. Many fragments of pottery, other objects, and coins of several Roman emperors, dating from 133 to 361, and perhaps to 375 A.D., were likewise found. Also a half-penny of George I., 1715. The presence of this latter coin seems an anomaly; but no doubt it was dropped on the ground during the last century, and since then there has been ample time for its burial under a considerable depth of the castings of worms. From the different dates of the Roman coins we may infer that the building was long inhabited. It was probably ruined and deserted 1400 or 1500 years ago.

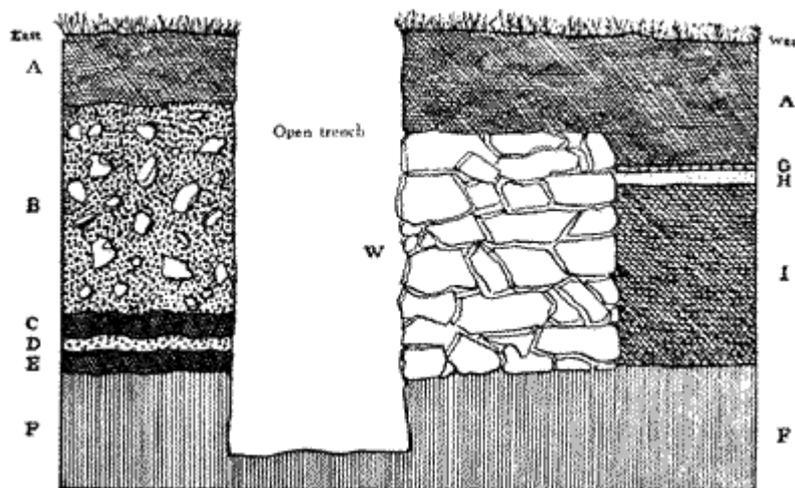


Fig. 8. Section through the foundations of a buried Roman villa at Abinger. A A, vegetable mould; B, dark earth full of stones, 13 in. in thickness; C, black mould; D, broken mortar; E, black mould; F F, undisturbed subsoil; G, tesserae; H, concrete; I, nature unknown; W, buried wall.

I was present during the commencement of the excavations (August 20, 1877) and Mr. Farrer had two deep trenches dug at opposite ends of the atrium, so that I might examine the nature of the soil near the remains. The field sloped from east to west at an angle of about 7 degrees; and one of the two trenches, shown in the accompanying section (Fig. 8) was at the upper or eastern end. The diagram is on a scale of 1/20 of an inch to an inch; but the trench, which was between 4 and 5 feet broad, and in parts above 5 feet deep, has necessarily been reduced out of all proportion. The fine mould over the floor of the atrium varied in thickness from 11 to

16 inches; and on the side of the trench in the section was a little over 13 inches. After the mould had been removed, the floor appeared as a whole moderately level; but it sloped in parts at an angle of 1 degree, and in one place near the outside at as much as 8 degrees 30 minutes. The wall surrounding the pavement was built of rough stones, and was 23 inches in thickness where the trench was dug. Its broken summit was here 13 inches, but in another part 15 inches, beneath the surface of the field, being covered by this thickness of mould. In one spot, however, it rose to within 6 inches of the surface. On two sides of the room, where the junction of the concrete floor with the bounding walls could be carefully examined, there was no crack or separation. This trench afterwards proved to have been dug within an adjoining room (11 ft. by 11 ft. 6 in. in size), the existence of which was not even suspected whilst I was present.

On the side of the trench farthest from the buried wall (W), the mould varied from 9 to 14 inches in thickness; it rested on a mass (B) 23 inches thick of blackish earth, including many large stones. Beneath this was a thin bed of very black mould (C), then a layer of earth full of fragments of mortar (D), and then another thin bed (about 3 inches thick) (E) of very black mould, which rested on the undisturbed subsoil (F) of firm, yellowish, argillaceous sand. The 23-inch bed (B) was probably made ground, as this would have brought up the floor of the room to a level with that of the atrium. The two thin beds of black mould at the bottom of the trench evidently marked two former land-surfaces. Outside the walls of the northern room, many bones, ashes, oyster-shells, broken pottery and an entire pot were subsequently found at a depth of 16 inches beneath the surface.

The second trench was dug on the western or lower side of the villa: the mould was here only 6.5 inches in thickness, and it rested on a mass of fine earth full of stones, broken tiles and fragments of mortar, 34 inches in thickness, beneath which was the undisturbed sand. Most of this earth had probably been washed down from the upper part of the field, and the fragments of stones, tiles, etc., must have come from the immediately adjoining ruins.

It appears at first sight a surprising fact that this field of light sandy soil should have been cultivated and ploughed during many years, and that not a vestige of these buildings should have been discovered. No one even suspected that the remains of a Roman villa lay hidden close beneath the surface. But the fact is less surprising when it is known that the field, as the bailiff believed, had never been ploughed to a greater depth than 4 inches. It is certain that when the land was first ploughed, the pavement and the surrounding broken walls must have been covered by at least 4 inches of soil, for otherwise the rotten concrete floor would have been scored by the ploughshare, the tesserae torn up, and the tops of the old walls knocked down.

When the concrete and tesserae were first cleared over a space of 14 by 9 ft., the floor which was coated with trodden-down earth exhibited no signs of having been penetrated by worms; and although the overlying fine mould closely resembled that which in many places has certainly been accumulated by worms, yet it seemed hardly possible that this mould could have been brought up by worms from beneath the apparently sound floor. It seemed also extremely improbable that the thick walls, surrounding the room and still united to the concrete, had been undermined by worms, and had thus been caused to sink, being afterwards covered up by their

castings. I therefore at first concluded that all the fine mould above the ruins had been washed down from the upper parts of the field; but we shall soon see that this conclusion was certainly erroneous, though much fine earth is known to be washed down from the upper part of the field in its present ploughed state during heavy rains.

Although the concrete floor did not at first appear to have been anywhere penetrated by worms, yet by the next morning little cakes of the trodden-down earth had been lifted up by worms over the mouths of seven burrows, which passed through the softer parts of the naked concrete, or between the interstices of the tesserae. On the third morning twenty-five burrows were counted; and by suddenly lifting up the little cakes of earth, four worms were seen in the act of quickly retreating. Two castings were thrown up during the third night on the floor, and these were of large size. The season was not favourable for the full activity of worms, and the weather had lately been hot and dry, so that most of the worms now lived at a considerable depth. In digging the two trenches many open burrows and some worms were encountered at between 30 and 40 inches beneath the surface; but at a greater depth they became rare. One worm, however, was cut through at 48.5, and another at 51.5 inches beneath the surface. A fresh humus-lined burrow was also met with at a depth of 57 and another at 65.5 inches. At greater depths than this, neither burrows nor worms were seen.

As I wished to learn how many worms lived beneath the floor of the atrium--a space of about 14 by 9 feet--Mr. Farrer was so kind as to make observations for me, during the next seven weeks, by which time the worms in the surrounding country were in full activity, and were working near the surface. It is very improbable that worms should have migrated from the adjoining field into the small space of the atrium, after the superficial mould in which they prefer to live, had been removed. We may therefore conclude that the burrows and the castings which were seen here during the ensuing seven weeks were the work of the former inhabitants of the space. I will now give a few extracts from Mr. Farrer's notes.

Aug. 26th, 1877; that is, five days after the floor had been cleared. On the previous night there had been some heavy rain, which washed the surface clean, and now the mouths of forty burrows were counted. Parts of the concrete were seen to be solid, and had never been penetrated by worms, and here the rain-water lodged.

Sept. 5th.--Tracks of worms, made during the previous night, could be seen on the surface of the floor, and five or six vermiform castings had been thrown up. These were defaced.

Sept. 12th.--During the last six days, the worms have not been active, though many castings have been ejected in the neighbouring fields; but on this day the earth was a little raised over the mouths of the burrows, or castings were ejected, at ten fresh points. These were defaced. It should be understood that when a fresh burrow is spoken of, this generally means only that an old burrow has been re-opened. Mr. Farrer was repeatedly struck with the pertinacity with which the worms re-opened their old burrows, even when no earth was ejected from them. I have often observed the same fact, and generally the mouths of the burrows are protected by an accumulation of pebbles, sticks or leaves. Mr. Farrer likewise observed that the

worms living beneath the floor of the atrium often collected coarse grains of sand, and such little stones as they could find, round the mouths of their burrows.

Sept. 13th; soft wet weather. The mouths of the burrows were re- opened, or castings were ejected, at 31 points; these were all defaced.

Sept. 14th; 34 fresh holes or castings; all defaced.

Sept. 15th; 44 fresh holes, only 5 castings; all defaced.

Sept. 18th; 43 fresh holes, 8 castings; all defaced.

The number of castings on the surrounding fields was now very large.

Sept. 19th; 40 holes, 8 castings; all defaced.

Sept. 22nd; 43 holes, only a few fresh castings; all defaced.

Sept. 23rd; 44 holes, 8 castings.

Sept. 25th; 50 holes, no record of the number of castings.

Oct. 13th; 61 holes, no record of the number of castings.

After an interval of three years, Mr. Farrer, at my request, again looked at the concrete floor, and found the worms still at work.

Knowing what great muscular power worms possess, and seeing how soft the concrete was in many parts, I was not surprised at its having been penetrated by their burrows; but it is a more surprising fact that the mortar between the rough stones of the thick walls, surrounding the rooms, was found by Mr. Farrer to have been penetrated by worms. On August 26th, that is, five days after the ruins had been exposed, he observed four open burrows on the broken summit of the eastern wall (W in Fig. 8); and, on September 15th, other burrows similarly situated were seen. It should also be noted that in the perpendicular side of the trench (which was much deeper than is represented in Fig. 8) three recent burrows were seen, which ran obliquely far down beneath the base of the old wall.

We thus see that many worms lived beneath the floor and the walls of the atrium at the time when the excavations were made; and that they afterwards almost daily brought up earth to the surface from a considerable depth. There is not the slightest reason to doubt that worms have acted in this manner ever since the period when the concrete was sufficiently decayed to allow them to penetrate it; and even before that period they would have lived beneath the floor, as soon as it became pervious to rain, so that the soil beneath was kept damp. The floor and the walls must therefore have been continually undermined; and fine earth must have been heaped on them during many centuries, perhaps for a thousand years. If the burrows beneath the floor and walls, which it is probable were formerly as numerous as they now are, had not collapsed in the course of time in the manner formerly explained, the underlying earth would have been riddled with passages like a sponge; and as this was not the

case, we may feel sure that they have collapsed. The inevitable result of such collapsing during successive centuries, will have been the slow subsidence of the floor and of the walls, and their burial beneath the accumulated worm-castings. The subsidence of a floor, whilst it still remains nearly horizontal, may at first appear improbable; but the case presents no more real difficulty than that of loose objects strewn on the surface of a field, which, as we have seen, become buried several inches beneath the surface in the course of a few years, though still forming a horizontal layer parallel to the surface. The burial of the paved and level path on my lawn, which took place under my own observation, is an analogous case. Even those parts of the concrete floor which the worms could not penetrate would almost certainly have been undermined, and would have sunk, like the great stones at Leith Hill Place and Stonehenge, for the soil would have been damp beneath them. But the rate of sinking of the different parts would not have been quite equal, and the floor was not quite level. The foundations of the boundary walls lie, as shown in the section, at a very small depth beneath the surface; they would therefore have tended to subside at nearly the same rate as the floor. But this would not have occurred if the foundations had been deep, as in the case of some other Roman ruins presently to be described.

Finally, we may infer that a large part of the fine vegetable mould, which covered the floor and the broken-down walls of this villa, in some places to a thickness of 16 inches, was brought up from below by worms. From facts hereafter to be given there can be no doubt that some of the finest earth thus brought up will have been washed down the sloping surface of the field during every heavy shower of rain. If this had not occurred a greater amount of mould would have accumulated over the ruins than that now present. But beside the castings of worms and some earth brought up by insects, and some accumulation of dust, much fine earth will have been washed over the ruins from the upper parts of the field, since it has been under cultivation; and from over the ruins to the lower parts of the slope; the present thickness of the mould being the resultant of these several agencies.

I may here append a modern instance of the sinking of a pavement, communicated to me in 1871 by Mr. Ramsay, Director of the Geological Survey of England. A passage without a roof, 7 feet in length by 3 feet 2 inches in width, led from his house into the garden, and was paved with slabs of Portland stone. Several of these slabs were 16 inches square, others larger, and some a little smaller. This pavement had subsided about 3 inches along the middle of the passage, and two inches on each side, as could be seen by the lines of cement by which the slabs had been originally joined to the walls. The pavement had thus become slightly concave along the middle; but there was no subsidence at the end close to the house. Mr. Ramsay could not account for this sinking, until he observed that castings of black mould were frequently ejected along the lines of junction between the slabs; and these castings were regularly swept away. The several lines of junction, including those with the lateral walls, were altogether 39 feet 2 inches in length. The pavement did not present the appearance of ever having been renewed, and the house was believed to have been built about eighty-seven years ago. Considering all these circumstances, Mr. Ramsay does not doubt that the earth brought up by the worms since the pavement was first laid down, or rather since the decay of the mortar allowed the worms to burrow through it, and therefore within a much shorter time than the eighty-seven years, has sufficed to cause the sinking of the pavement to the

above amount, except close to the house, where the ground beneath would have been kept nearly dry.

Beaulieu Abbey, Hampshire.--This abbey was destroyed by Henry VIII., and there now remains only a portion of the southern aisle- wall. It is believed that the king had most of the stones carried away for building a castle; and it is certain that they have been removed. The positions of the nave and transepts were ascertained not long ago by the foundations having been found; and the place is now marked by stones let into the ground. Where the abbey formerly stood, there now extends a smooth grass-covered surface, which resembles in all respects the rest of the field. The guardian, a very old man, said the surface had never been levelled in his time. In the year 1853, the Duke of Buccleuch had three holes dug in the turf within a few yards of one another, at the western end of the nave; and the old tessellated pavement of the abbey was thus discovered. These holes were afterwards surrounded by brickwork, and protected by trap-doors, so that the pavement might be readily inspected and preserved. When my son William examined the place on January 5, 1872, he found that the pavement in the three holes lay at depths of 6.75, 10 and 11.5 inches beneath the surrounding turf- covered surface. The old guardian asserted that he was often forced to remove worm-castings from the pavement; and that he had done so about six months before. My son collected all from one of the holes, the area of which was 5.32 square feet, and they weighed 7.97 ounces. Assuming that this amount had accumulated in six months, the accumulation during a year on a square yard would be 1.68 pounds, which, though a large amount, is very small compared with what, as we have seen, is often ejected on fields and commons. When I visited the abbey on June 22, 1877, the old man said that he had cleared out the holes about a month before, but a good many castings had since been ejected. I suspect that he imagined that he swept the pavements oftener than he really did, for the conditions were in several respects very unfavourable for the accumulation of even a moderate amount of castings. The tiles are rather large, viz., about 5.5 inches square, and the mortar between them was in most places sound, so that the worms were able to bring up earth from below only at certain points. The tiles rested on a bed of concrete, and the castings in consequence consisted in large part (viz., in the proportion of 19 to 33) of particles of mortar, grains of sand, little fragments of rock, bricks or tile; and such substances could hardly be agreeable, and certainly not nutritious, to worms.

My son dug holes in several places within the former walls of the abbey, at a distance of several yards from the above described bricked squares. He did not find any tiles, though these are known to occur in some other parts, but he came in one spot to concrete on which tiles had once rested. The fine mould beneath the turf on the sides of the several holes, varied in thickness from only 2 to 2.75 inches, and this rested on a layer from 8.75 to above 11 inches in thickness, consisting of fragments of mortar and stone- rubbish with the interstices compactly filled up with black mould. In the surrounding field, at a distance of 20 yards from the abbey, the fine vegetable mould was 11 inches thick.

We may conclude from these facts that when the abbey was destroyed and the stones removed, a layer of rubbish was left over the whole surface, and that as soon as the worms were able to penetrate the decayed concrete and the joints between the tiles, they slowly filled up the interstices in the overlying rubbish with their

castings, which were afterwards accumulated to a thickness of nearly three inches over the whole surface. If we add to this latter amount the mould between the fragments of stones, some five or six inches of mould must have been brought up from beneath the concrete or tiles. The concrete or tiles will consequently have subsided to nearly this amount. The bases of the columns of the aisles are now buried beneath mould and turf. It is not probable that they can have been undermined by worms, for their foundations would no doubt have been laid at a considerable depth. If they have not subsided, the stones of which the columns were constructed must have been removed from beneath the former level of the floor.

Chedworth, Gloucestershire.--The remains of a large Roman villa were discovered here in 1866, on ground which had been covered with wood from time immemorial. No suspicion seems ever to have been entertained that ancient buildings lay buried here, until a gamekeeper, in digging for rabbits, encountered some remains. {55} But subsequently the tops of some stone walls were detected in parts of the wood, projecting a little above the surface of the ground. Most of the coins found here belonged to Constans (who died 350 A.D.) and the Constantine family. My sons Francis and Horace visited the place in November 1877, for the sake of ascertaining what part worms may have played in the burial of these extensive remains. But the circumstances were not favourable for this object, as the ruins are surrounded on three sides by rather steep banks, down which earth is washed during rainy weather. Moreover most of the old rooms have been covered with roofs, for the protection of the elegant tessellated pavements.

A few facts may, however, be given on the thickness of the soil over these ruins. Close outside the northern rooms there is a broken wall, the summit of which was covered by 5 inches of black mould; and in a hole dug on the outer side of this wall, where the ground had never before been disturbed, black mould, full of stones, 26 inches in thickness, was found, resting on the undisturbed sub-soil of yellow clay. At a depth of 22 inches from the surface a pig's jaw and a fragment of a tile were found. When the excavations were first made, some large trees grew over the ruins; and the stump of one has been left directly over a party-wall near the bath-room, for the sake of showing the thickness of the superincumbent soil, which was here 38 inches. In one small room, which, after being cleared out, had not been roofed over, my sons observed the hole of a worm passing through the rotten concrete, and a living worm was found within the concrete. In another open room worm-castings were seen on the floor, over which some earth had by this means been deposited, and here grass now grew.

Brading, Isle of Wight.--A fine Roman villa was discovered here in 1880; and by the end of October no less than 18 chambers had been more or less cleared. A coin dated 337 A.D. was found. My son William visited the place before the excavations were completed; and he informs me that most of the floors were at first covered with much rubbish and fallen stones, having their interstices completely filled up with mould, abounding, as the workmen said, with worms, above which there was mould without any stones. The whole mass was in most places from 3 to above 4 ft. in thickness. In one very large room the overlying earth was only 2 ft. 6 in. thick; and after this had been removed, so many castings were thrown up between the tiles that the surface had to be almost daily swept. Most of the floors were fairly level. The tops of the broken-down walls were covered in some places by only 4 or 5 inches of

soil, so that they were occasionally struck by the plough, but in other places they were covered by from 13 to 18 inches of soil. It is not probable that these walls could have been undermined by worms and subsided, as they rested on a foundation of very hard red sand, into which worms could hardly burrow. The mortar, however, between the stones of the walls of a hypocaust was found by my son to have been penetrated by many worm-burrows. The remains of this villa stand on land which slopes at an angle of about 3 degrees; and the land appears to have been long cultivated. Therefore no doubt a considerable quantity of fine earth has been washed down from the upper parts of the field, and has largely aided in the burial of these remains.

Silchester, Hampshire.--The ruins of this small Roman town have been better preserved than any other remains of the kind in England. A broken wall, in most parts from 15 to 18 feet in height and about 1.5 mile in compass, now surrounds a space of about 100 acres of cultivated land, on which a farm-house and a church stand. {56} Formerly, when the weather was dry, the lines of the buried walls could be traced by the appearance of the crops; and recently very extensive excavations have been undertaken by the Duke of Wellington, under the superintendence of the late Rev. J. G. Joyce, by which means many large buildings have been discovered. Mr. Joyce made careful coloured sections, and measured the thickness of each bed of rubbish, whilst the excavations were in progress; and he has had the kindness to send me copies of several of them. When my sons Francis and Horace visited these ruins, he accompanied them, and added his notes to theirs.

Mr. Joyce estimates that the town was inhabited by the Romans for about three centuries; and no doubt much matter must have accumulated within the walls during this long period. It appears to have been destroyed by fire, and most of the stones used in the buildings have since been carried away. These circumstances are unfavourable for ascertaining the part which worms have played in the burial of the ruins; but as careful sections of the rubbish overlying an ancient town have seldom or never before been made in England, I will give copies of the most characteristic portions of some of those made by Mr. Joyce. They are of too great length to be here introduced entire.

An east and west section, 30 ft. in length, was made across a room in the Basilica, now called the Hall of the Merchants (Fig. 9). The hard concrete floor, still covered here and there with tesserae, was found at 3 ft. beneath the surface of the field, which was here level. On the floor there were two large piles of charred wood, one alone of which is shown in the part of the section here given. This pile was covered by a thin white layer of decayed stucco or plaster, above which was a mass, presenting a singularly disturbed appearance, of broken tiles, mortar, rubbish and fine gravel, together 27 inches in thickness. Mr. Joyce believes that the gravel was used in making the mortar or concrete, which has since decayed, some of the lime probably having been dissolved. The disturbed state of the rubbish may have been due to its having been searched for building stones. This bed was capped by fine vegetable mould, 9 inches in thickness. From these facts we may conclude that the Hall was burnt down, and that much rubbish fell on the floor, through and from which the worms slowly brought up the mould, now forming the surface of the level field.

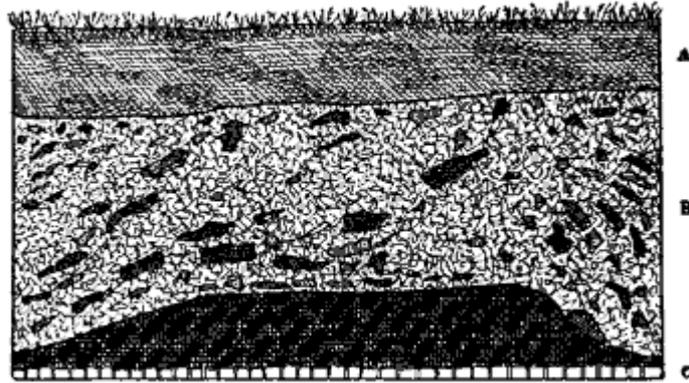


Fig. 9. Section within a room in the Basilica at Silchester. Scale 1/18. A, Mould 9 inches thick; B, mass of rubbish, 27 in. thick, overlying a pile of charred wood; C, Tesserae resting on concrete.

A section across the middle of another hall in the Basilica, 32 feet 6 inches in length, called the AErarium, is shown in Fig. 10. It appears that we have here evidence of two fires, separated by an interval of time, during which the 6 inches of "mortar and concrete with broken tiles" was accumulated. Beneath one of the layers of charred wood, a valuable relic, a bronze eagle, was found; and this shows that the soldiers must have deserted the place in a panic. Owing to the death of Mr. Joyce, I have not been able to ascertain beneath which of the two layers the eagle was found. The bed of rubble overlying the undisturbed gravel originally formed, as I suppose, the floor, for it stands on a level with that of a corridor, outside the walls of the Hall; but the corridor is not shown in the section as here given. The vegetable mould was 16 inches thick in the thickest part; and the depth from the surface of the field, clothed with herbage, to the undisturbed gravel, was 40 inches.



Fig. 10. Section within a room in the Basilica at Silchester. Scale 1/32. A, Mould 16 in. thick; B, Charred wood 10 in. thick; C, Mortar with broken tiles 6 in. thick; D, Charred wood 2 in. thick; E, Rubble 6 in. thick; F, Undisturbed gravel.

The section shown in Fig. 11 represents an excavation made in the middle of the town, and is here introduced because the bed of "rich mould" attained, according to Mr. Joyce, the unusual thickness of 20 inches. Gravel lay at the depth of 48 inches from the surface; but it was not ascertained whether this was in its natural state, or had been brought here and had been rammed down, as occurs in some other places.

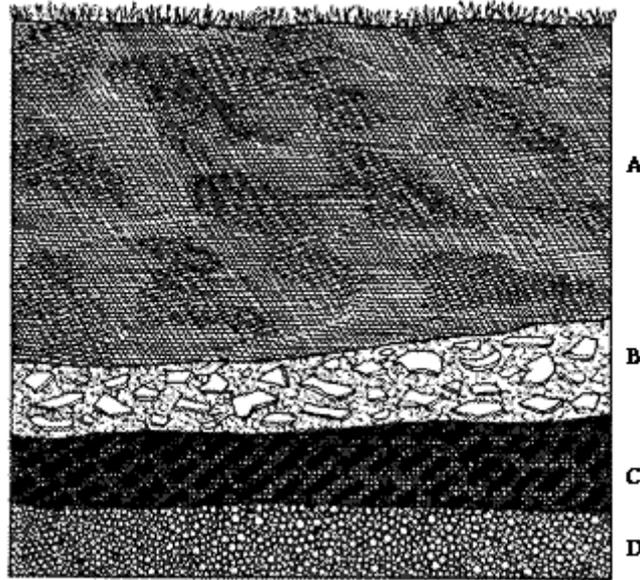


Fig. 11. Section in a block of buildings in the middle of the town of Silchester. A, Mould 20 in. thick; B, Rubble with broken tiles 4 in. thick; C, Black decayed wood in thickest part 6 in. thick; D, Gravel.

The section shown in Fig. 12 was taken in the centre of the Basilica, and though it was 5 feet in depth, the natural sub-soil was not reached. The bed marked "concrete" was probably at one time a floor; and the beds beneath seem to be the remnants of more ancient buildings. The vegetable mould was here only 9 inches thick. In some other sections, not copied, we likewise have evidence of buildings having been erected over the ruins of older ones. In one case there was a layer of yellow clay of very unequal thickness between two beds of debris, the lower one of which rested on a floor with tesserae. The ancient broken walls appear to have been sometimes roughly cut down to a uniform level, so as to serve as the foundations for a temporary building; and Mr. Joyce suspects that some of these buildings were wattled sheds, plastered with clay, which would account for the above-mentioned layer of clay.

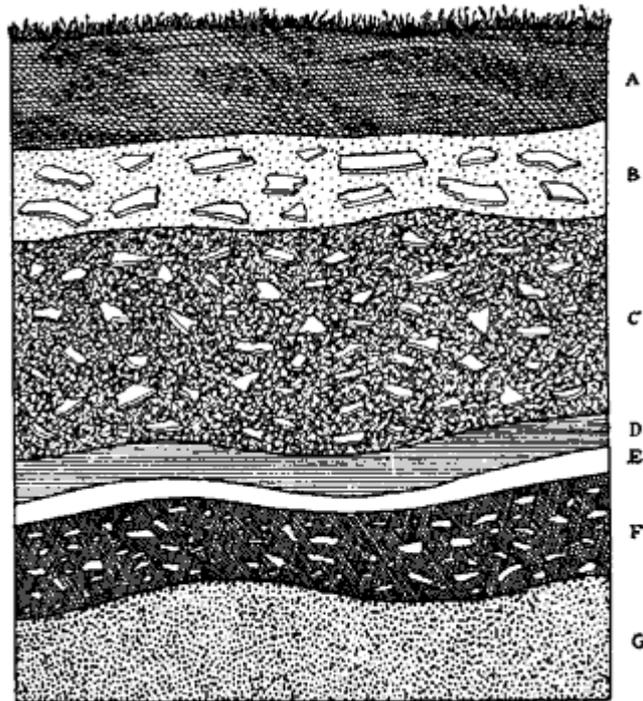


Fig. 12. Section in the centre of the Basilica at Silchester. A, Mould 9 in. thick; B, light-coloured earth with large pieces of broken tiles, 7 in.; C, Dark, fine-grained rubbish with small bits of tiles, 20 in.; D, Concrete, 4 in.; E, Stucco, 2 in.; F, Made bottom with fragment of tiles, 8 in.; G, Fine-grained made ground, with the debris of older buildings.

Turning now to the points which more immediately concern us. Worm-castings were observed on the floors of several of the rooms, in one of which the tessellation was unusually perfect. The tesserae here consisted of little cubes of hard sandstone of about 1 inch, several of which were loose or projected slightly above the general level. One or occasionally two open worm-burrows were found beneath all the loose tesserae. Worms have also penetrated the old walls of these ruins. A wall, which had just been exposed to view during the excavations then in progress, was examined; it was built of large flints, and was 18 inches in thickness. It appeared sound, but when the soil was removed from beneath, the mortar in the lower part was found to be so much decayed that the flints fell apart from their own weight. Here, in the middle of the wall, at a depth of 29 inches beneath the old floor and of 49.5 inches beneath the surface of the field, a living worm was found, and the mortar was penetrated by several burrows.

A second wall was exposed to view for the first time, and an open burrow was seen on its broken summit. By separating the flints this burrow was traced far down in the interior of the wall; but as some of the flints cohered firmly, the whole mass was disturbed in pulling down the wall, and the burrow could not be traced to the bottom. The foundations of a third wall, which appeared quite sound, lay at a depth of 4 feet beneath one of the floors, and of course at a considerably greater depth beneath the level of the ground. A large flint was wrenched out of the wall at about a foot from the base, and this required much force, as the mortar was sound; but behind the flint in the middle of the wall, the mortar was friable, and here there were worm-burrows.

Mr. Joyce and my sons were surprised at the blackness of the mortar in this and in several other cases, and at the presence of mould in the interior of the walls. Some may have been placed there by the old builders instead of mortar; but we should remember that worms line their burrows with black humus. Moreover open spaces would almost certainly have been occasionally left between the large irregular flints; and these spaces, we may feel sure, would be filled up by the worms with their castings, as soon as they were able to penetrate the wall. Rain-water, oozing down the burrows would also carry fine dark-coloured particles into every crevice. Mr. Joyce was at first very sceptical about the amount of work which I attributed to worms; but he ends his notes with reference to the last-mentioned wall by saying, "This case caused me more surprise and brought more conviction to me than any other. I should have said, and did say, that it was quite impossible such a wall could have been penetrated by earth-worms."

In almost all the rooms the pavement has sunk considerably, especially towards the middle; and this is shown in the three following sections. The measurements were made by stretching a string tightly and horizontally over the floor. The section, Fig. 13, was taken from north to south across a room, 18 feet 4 inches in length, with a nearly perfect pavement, next to the "Red Wooden Hut." In the northern half, the subsidence amounted to 5.75 inches beneath the level of the floor as it now stands close to the walls; and it was greater in the northern than in the southern half; but, according to Mr. Joyce, the entire pavement has obviously subsided. In several places, the tesserae appeared as if drawn a little away from the walls; whilst in other places they were still in close contact with them.

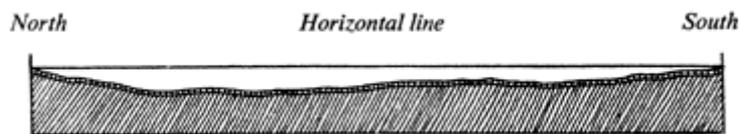


Fig. 13. Section of the subsided floor of a room, paved with tesserae, at Silchester. Scale 1/40.

In Fig. 14, we see a section across the paved floor of the southern corridor or ambulatory of a quadrangle, in an excavation made near "The Spring." The floor is 7 feet 9 inches wide, and the broken-down walls now project only 0.75 of an inch above its level. The field, which was in pasture, here sloped from north to south, at an angle of 30 degrees, 40 seconds. The nature of the ground at some little distance on each side of the corridor is shown in the section. It consisted of earth full of stones and other debris, capped with dark vegetable mould which was thicker on the lower or southern than on the northern side. The pavement was nearly level along lines parallel to the side-walls, but had sunk in the middle as much as 7.75 inches.

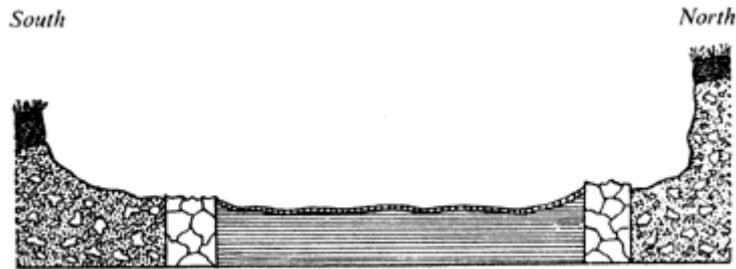


Fig. 14. A north and south section through the subsided floor of a corridor, paved with tesserae. Outside the broken-down bounding walls, the excavated ground on each side is shown for a short space. Nature of the ground beneath the tesserae unknown. Silchester. Scale 1/40.

A small room at no great distance from that represented in Fig. 13, had been enlarged by the Roman occupier on the southern side, by an addition of 5 feet 4 inches in breadth. For this purpose the southern wall of the house had been pulled down, but the foundations of the old wall had been left buried at a little depth beneath the pavement of the enlarged room. Mr. Joyce believes that this buried wall must have been built before the reign of Claudius II., who died 270 A.D. We see in the accompanying section, Fig. 15, that the tessellated pavement has subsided to a less degree over the buried wall than elsewhere; so that a slight convexity or protuberance here stretched in a straight line across the room. This led to a hole being dug, and the buried wall was thus discovered.

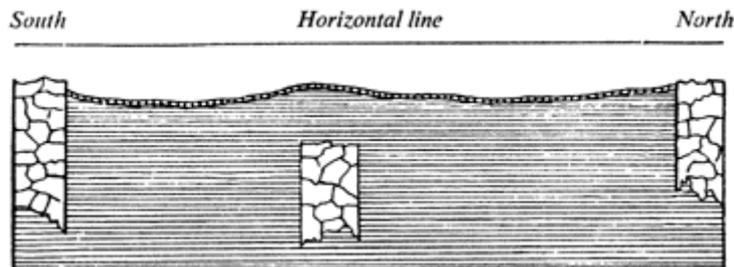


Fig. 15. Section of the subsided floor, paved with tesserae, and of the broken-down bounding walls of a room at Silchester, which had been formerly enlarged, with the foundations of the old wall left buried. Scale 1/40.

We see in these three sections, and in several others not given, that the old pavements have sunk or sagged considerably. Mr. Joyce formerly attributed this sinking solely to the slow settling of the ground. That there has been some settling is highly probable, and it may be seen in Fig. 15 that the pavement for a width of 5 feet over the southern enlargement of the room, which must have been built on fresh ground, has sunk a little more than on the old northern side. But this sinking may possibly have had no connection with the enlargement of the room; for in Fig. 13 one half of the pavement has subsided more than the other half without any assignable cause. In a bricked passage to Mr. Joyce's own house, laid down only about six years ago, the same kind of sinking has occurred as in the ancient buildings. Nevertheless it does not appear probable that the whole amount of sinking can be thus accounted for. The Roman builders excavated the ground to an unusual depth

for the foundations of their walls, which were thick and solid; it is therefore hardly credible that they should have been careless about the solidity of the bed on which their tessellated and often ornamented pavements were laid. The sinking must, as it appears to me, be attributed in chief part to the pavement having been undermined by worms, which we know are still at work. Even Mr. Joyce at last admitted that this could not have failed to have produced a considerable effect. Thus also the large quantity of fine mould overlying the pavements can be accounted for, the presence of which would otherwise be inexplicable. My sons noticed that in one room in which the pavement had sagged very little, there was an unusually small amount of overlying mould.

As the foundations of the walls generally lie at a considerable depth, they will either have not subsided at all through the undermining action of worms, or they will have subsided much less than the floor. This latter result would follow from worms not often working deep down beneath the foundations; but more especially from the walls not yielding when penetrated by worms, whereas the successively formed burrows in a mass of earth, equal to one of the walls in depth and thickness, would have collapsed many times since the desertion of the ruins, and would consequently have shrunk or subsided. As the walls cannot have sunk much or at all, the immediately adjoining pavement from adhering to them will have been prevented from subsiding; and thus the present curvature of the pavement is intelligible.

The circumstance which has surprised me most with respect to Silchester is that during the many centuries which have elapsed since the old buildings were deserted, the vegetable mould has not accumulated over them to a greater thickness than that here observed. In most places it is only about 9 inches in thickness, but in some places 12 or even more inches. In Fig. 11, it is given as 20 inches, but this section was drawn by Mr. Joyce before his attention was particularly called to this subject. The land enclosed within the old walls is described as sloping slightly to the south; but there are parts which, according to Mr. Joyce, are nearly level, and it appears that the mould is here generally thicker than elsewhere. The surface slopes in other parts from west to east, and Mr. Joyce describes one floor as covered at the western end by rubbish and mould to a thickness of 28.5 inches, and at the eastern end by a thickness of only 11.5 inches. A very slight slope suffices to cause recent castings to flow downwards during heavy rain, and thus much earth will ultimately reach the neighbouring rills and streams and be carried away. By this means, the absence of very thick beds of mould over these ancient ruins may, as I believe, be explained. Moreover most of the land here has long been ploughed, and this would greatly aid the washing away of the finer earth during rainy weather.

The nature of the beds immediately beneath the vegetable mould in some of the sections is rather perplexing. We see, for instance, in the section of an excavation in a grass meadow (Fig. 14), which sloped from north to south at an angle of 30 degrees 40 seconds, that the mould on the upper side is only six inches and on the lower side nine inches in thickness. But this mould lies on a mass (25.5 inches in thickness on the upper side) "of dark brown mould," as described by Mr. Joyce, "thickly interspersed with small pebbles and bits of tiles, which present a corroded or worn appearance. The state of this dark-coloured earth is like that of a field which has long been ploughed, for the earth thus becomes intermingled with stones and fragments of all kinds which have been much exposed to the weather. If during the

course of many centuries this grass meadow and the other now cultivated fields have been at times ploughed, and at other times left as pasture, the nature of the ground in the above section is rendered intelligible. For worms will continually have brought up fine earth from below, which will have been stirred up by the plough whenever the land was cultivated. But after a time a greater thickness of fine earth will thus have been accumulated than could be reached by the plough; and a bed like the 25.5-inch mass, in Fig. 14, will have been formed beneath the superficial mould, which latter will have been brought to the surface within more recent times, and have been well sifted by the worms.

Wroxeter, Shropshire. --The old Roman city of Uriconium was founded in the early part of the second century, if not before this date; and it was destroyed, according to Mr. Wright, probably between the middle of the fourth and fifth century. The inhabitants were massacred, and skeletons of women were found in the hypocausts. Before the year 1859, the sole remnant of the city above ground, was a portion of a massive wall about 20 ft. in height. The surrounding land undulates slightly, and has long been under cultivation. It had been noticed that the corn-crops ripened prematurely in certain narrow lines, and that the snow remained unmelted in certain places longer than in others. These appearances led, as I was informed, to extensive excavations being undertaken. The foundations of many large buildings and several streets have thus been exposed to view. The space enclosed within the old walls is an irregular oval, about 1 mile in length. Many of the stones or bricks used in the buildings must have been carried away; but the hypocausts, baths, and other underground buildings were found tolerably perfect, being filled with stones, broken tiles, rubbish and soil. The old floors of various rooms were covered with rubble. As I was anxious to know how thick the mantle of mould and rubbish was, which had so long concealed these ruins, I applied to Dr. H. Johnson, who had superintended the excavations; and he, with the greatest kindness, twice visited the place to examine it in reference to my questions, and had many trenches dug in four fields which had hitherto been undisturbed. The results of his observations are given in the following Table. He also sent me specimens of the mould, and answered, as far as he could, all my questions.

Measurements By Dr. H. Johnson Of The Thickness Of The Vegetable
Mould Over The Roman Ruins At Wroxeter.

Trenches dug in a field called "Old Works."

(Thickness of mould in inches shown in parenthesis--DP.)

1. At a depth of 36 inches undisturbed sand was reached (20)
2. At a depth of 33 inches concrete was reached (21)
3. At a depth of 9 inches concrete was reached (9)

Trenches dug in a field called "Shop Leasows;" this is the highest field within the old walls, and slopes down from a sub-central

point on all sides at about an angle of 2 degrees.

4. Summit of field, trench 45 inches deep (40)
5. Close to summit of field, trench 36 inches deep (26)
6. Close to summit of field, trench 28 inches deep (28)
7. Near summit of field, trench 36 inches deep (24)
8. Near summit of field, trench at one end 39 inches deep; the mould here graduated into the underlying undisturbed sand, and its thickness (24 inches) is somewhat arbitrary. At the other end of the trench, a causeway was encountered at a depth of only 7 inches, and the mould was here only 7 inches thick (24)
9. Trench close to the last, 28 inches in depth (24)
10. Lower part of same field, trench 30 inches deep (15)
11. Lower part of same field, trench 31 inches deep (17)
12. Lower part of same field, trench 36 inches deep, at which depth undisturbed sand was reached (28)
13. In another part of same field, trench 9.5 inches deep stopped by concrete (9.5)
14. In another part of same field, trench 9 inches deep, stopped by concrete (9)
15. In another part of the same field, trench 24 inches deep, when sand was reached (16)
16. In another part of same field, trench 30 inches deep, when stones were reached; at one end of the trench mould 12 inches, at the other end 14 inches thick (13)

Small field between "Old Works" and "Shop Leasows," I believe nearly as high as the upper part of the latter field.

17. Trench 26 inches deep (24)
18. Trench 10 inches deep, and then came upon a causeway (10)
19. Trench 34 inches deep (30)
20. Trench 31 inches deep (31)

Field on the western side of the space enclosed within the old

walls.

21. Trench 28 inches deep, when undisturbed sand was reached (16)

22. Trench 29 inches deep, when undisturbed sand was reached (15)

23. Trench 14 inches deep, and then came upon a building (14)

Dr. Johnson distinguished as mould the earth which differed, more or less abruptly, in its dark colour and in its texture from the underlying sand or rubble. In the specimens sent to me, the mould resembled that which lies immediately beneath the turf in old pasture-land, excepting that it often contained small stones, too large to have passed through the bodies of worms. But the trenches above described were dug in fields, none of which were in pasture, and all had been long cultivated. Bearing in mind the remarks made in reference to Silchester on the effects of long-continued culture, combined with the action of worms in bringing up the finer particles to the surface, the mould, as so designated by Dr. Johnson, seems fairly well to deserve its name. Its thickness, where there was no causeway, floor or walls beneath, was greater than has been elsewhere observed, namely, in many places above 2 ft., and in one spot above 3 ft. The mould was thickest on and close to the nearly level summit of the field called "Shop Leasows," and in a small adjoining field, which, as I believe, is of nearly the same height. One side of the former field slopes at an angle of rather above 2 degrees, and I should have expected that the mould, from being washed down during heavy rain, would have been thicker in the lower than in the upper part; but this was not the case in two out of the three trenches here dug.

In many places, where streets ran beneath the surface, or where old buildings stood, the mould was only 8 inches in thickness; and Dr. Johnson was surprised that in ploughing the land, the ruins had never been struck by the plough as far as he had heard. He thinks that when the land was first cultivated the old walls were perhaps intentionally pulled down, and that hollow places were filled up. This may have been the case; but if after the desertion of the city the land was left for many centuries uncultivated, worms would have brought up enough fine earth to have covered the ruins completely; that is if they had subsided from having been undermined. The foundations of some of the walls, for instance those of the portion still standing about 20 feet above the ground, and those of the marketplace, lie at the extraordinary depth of 14 feet; but it is highly improbable that the foundations were generally so deep. The mortar employed in the buildings must have been excellent, for it is still in parts extremely hard. Wherever walls of any height have been exposed to view, they are, as Dr. Johnson believes, still perpendicular. The walls with such deep foundations cannot have been undermined by worms, and therefore cannot have subsided, as appears to have occurred at Abinger and Silchester. Hence it is very difficult to account for their being now completely covered with earth; but how much of this covering consists of vegetable mould and how much of rubble I do not know. The market-place, with the foundations at a depth of 14 feet, was covered up, as Dr. Johnson believes, by between 6 and 24 inches of earth. The tops of the broken-down walls of a caldarium or bath, 9 feet in depth, were likewise covered up with

nearly 2 feet of earth. The summit of an arch, leading into an ash-pit 7 feet in depth, was covered up with not more than 8 inches of earth. Whenever a building which has not subsided is covered with earth, we must suppose, either that the upper layers of stone have been at some time carried away by man, or that earth has since been washed down during heavy rain, or blown down during storms, from the adjoining land; and this would be especially apt to occur where the land has long been cultivated. In the above cases the adjoining land is somewhat higher than the three specified sites, as far as I can judge by maps and from information given me by Dr. Johnson. If; however, a great pile of broken stones, mortar, plaster, timber and ashes fell over the remains of any building, their disintegration in the course of time, and the sifting action of worms, would ultimately conceal the whole beneath fine earth.

Conclusion. --The cases given in this chapter show that worms have played a considerable part in the burial and concealment of several Roman and other old buildings in England; but no doubt the washing down of soil from the neighbouring higher lands, and the deposition of dust, have together aided largely in the work of concealment. Dust would be apt to accumulate wherever old broken-down walls projected a little above the then existing surface and thus afforded some shelter. The floors of the old rooms, halls and passages have generally sunk, partly from the settling of the ground, but chiefly from having been undermined by worms; and the sinking has commonly been greater in the middle than near the walls. The walls themselves, whenever their foundations do not lie at a great depth, have been penetrated and undermined by worms, and have consequently subsided. The unequal subsidence thus caused, probably explains the great cracks which may be seen in many ancient walls, as well as their inclination from the perpendicular.